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Hazardous Chemical Releases Occurring in School Settings, 14 States, 2008–2013

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Abstract

Children are considered to be a vulnerabletion when it comes to exposures to hazardous substances. Schools, where children spend about one third of their day, are expected to be a safe environment. Yet, there are many hazardous substances in schools that can be inadvertently or intentionally released and harm the health of students and teachers alike. The purpose of this analysis is to characterize acute chemical release incidents in school settings and identify prevention practices.

The acute chemical incident surveillance programs of the Agency for Toxic Substances and Disease Registry (ATSDR) captured 24,748 acute chemical release incidents from 14 states that participated during 2008–2013. We examined 335 of these incidents that occurred at schools. While only 1.3% (n = 335) of all chemical incidents reported to ATSDR occurred in schools, these incidents represented a larger part of the total impacts, including 8.5% of incidents with persons injured, 5.7% of evacuations ordered, and 31.1% of people evacuated. Natural gas (21.8%) and mercury (18.2%) were the chemicals most frequently released.

Collecting and analyzing data on acute school chemical releases allows stakeholders to target prevention initiatives and provide a school environment safe from these chemical exposures.

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Introduction

According to the National Center for Education Statistics, approximately 54 million students attended 116,240 public and private elementary and secondary schools within the U.S. during the 2011–2012 school year (Bitterman, Gray, & Goldring, 2013). Children spend about one third of their day in school, where they should be provided a healthy learning environment. Many factors, however, can lead to substandard environmental conditions in schools, which can result in serious health problems for students (U.S. Environmental Protection Agency [U.S. EPA], 2017a), as well as for school employees. School buildings contain chemicals of varying toxicity for sanitation, pest control, and for educational purposes, such as supplies in science laboratories, art classrooms, automotive repair areas, and vocational arts workshops (Berkowitz, Haugh, Orr, & Kaye, 2002).

Children are inherently more susceptible and vulnerable to many environmental hazards because of their developing bodies and age-associated behaviors (U.S. EPA, 2017a). Studies have shown that student exposure to hazardous chemicals in schools can result in poor academic performance, respiratory issues, and increases in school absenteeism (U.S. EPA, 2017a). Along with the physical and cognitive hazards to children, acute chemical releases in schools impose enormous financial and economic hardships on schools and communities. Remediation, teachers' lost work time, and evacuations can be extremely costly. For example, a school mercury incident in Texas required approximately $900,000 to test and cleanup all of the school's 137,000 square feet (Blaney, 2014), while another incident in Alabama required a 2-week, $517,247 cleanup (Leech, 2013).

News media outlets sometimes report acute hazardous chemical releases in schools. Outside of media reports, however, no single system is responsible for capturing all school chemical releases in the U.S. Therefore, quantifying or characterizing the nature of the incidents and their public health impacts is difficult. To better understand acute chemical incidents at schools and their public health impacts, we analyzed data from the 14 states that participated in the Agency for Toxic Substances and Disease Registry (ATSDR) Hazardous Substances Emergency Events Surveillance (HSEES) system and the National Toxic Substance Incidents Program (NTSIP).

Methods

Our analysis reviewed ATSDR's HSEES (2008–2009) and NTSIP (2010–2013) data. During various periods within this time frame, a total of 14 states participated (Colorado, Florida, Iowa, Louisiana, Michigan, Minnesota, New York, North Carolina, Oregon, Tennessee, Texas, Utah, Washington, and Wisconsin). From 1990–2009, HSEES was a state-based surveillance system used to track the public health impacts of hazardous substance releases (e.g., morbidity, mortality). NTSIP began in 2010 and continued with hazardous substance releases tracking and added a national component and mass incident investigations component (for more information about the HSEES program, please go to www.atsdr.cdc.gov/HS/hsees/Public_Use_File.html and for NTSIP, please go to www.atsdr.cdc.gov/ntsip).

Surveillance states used various data reporting sources, including state and local environmental protection agencies, police and fire departments, poison control centers, hospitals, local media, and various federal databases (e.g., U.S. Department of Transportation's Hazardous Materials Incident Reporting Systems and U.S. Coast Guard's National Response Center) to collect data on incidents, which was then entered into a secure web-based application.

A major difference in case definition between the two databases is that petroleum (natural gas, crude oil, etc.) incidents were excluded from HSEES unless another hazardous substance was also released; petroleum incidents were included in NTSIP if there was a public health impact such as an evacuation or injury (Agency for Toxic Substances and Disease Registry [ATSDR], 2016b). To identify releases that occurred in school settings (school chemical releases), we used the North American Industry Classification System (NAICS) code number 6111, which included both elementary and secondary schools and manually reviewed the comments and synopsis sections in the HSEES/NTSIP databases to verify that the incidents occurred in elementary or secondary schools.

We performed descriptive analysis of the data using SAS version 9.2.

Results

A total of 24,748 chemical incidents (that included multiple and single chemical releases) were captured during the 6-year (2008–2013) surveillance period. Only 1.3% (n = 335) of incidents occurred at schools, 57.3% (n = 192) of these incidents resulted in 47,433 persons evacuated (median = 305 persons) (Table 1). The range of hours for evacuations was 15 min to 1,392 hr (median = 2 hr). Only one incident reported an evacuation that lasted 56 days and 18 hr (1,392 hr). This incident occurred in an elementary school where mercury was released in a classroom. A beaker fell from a student's hand and released mercury. Students were moved to another room. A hazmat team was called; access to the classroom where the incident occurred and a section of the adjacent hallway was restricted and ventilation was shut down.

As a comparison, even though over half (57.3%) of school chemical incidents resulted in an evacuation being ordered, nonschool incidents had a lower percentage of evacuations (13%). The lower percentage of non-school evacuations could be because there were more nonschool incidents reported than school chemical releases. There was one incident, however, that led to an evacuation that lasted 111 days (2,664 hr). This single incident was a gas release that occurred in a private residence.

The public health actions that took place after many of the school chemical incidents included environmental sampling (n = 129 incidents), health investigations (n = 2 incidents), water intake shutdown (n = 1 incident), alternative water provision (n = 1 incident), and a health advisory issuance (n = 1 incident). The most commonly reported contributing factors for acute school chemical releases were human error (49%), equipment failure (32%), and intentional acts (15%) (Figure 1).

Natural gas, mercury, and carbon monoxide were the most frequently reported chemicals released in schools, accounting for almost one half (46.3%) of all school incidents. These chemicals also accounted for almost 60% of all evacuations ordered and people evacuated (Table 2). Compared with other chemicals, carbon monoxide was associated with the highest percentage of injured persons (20.1%), followed by pepper spray incidents (11%) (Table 2).

Forty-one (12.2%) of the incidents occurred in school laboratories, and over half (n = 22) of these were associated with injuries (a total of 88 injured persons). Fourteen (4.2%) incidents involved cleaning/disinfecting chemicals, which were associated with 48 injured persons. Swimming pool chemicals were reported in 12 (3.6%) incidents and were associated with 31 injured persons. Injuries were reported in 119 (35.5%) of the school chemical releases, with a total of 712 injured persons (Table 1).

Students accounted for 62.1% (n = 442) of injured persons, and nonstudents (defined as school employees, general public, and responders) accounted for 37.9% (n = 270). A majority, 57.3%, of the injured persons (n = 408) were treated at a hospital but not admitted, and another 12.5% (n = 89) were treated at the scene (Table 3). A total of 1,013 injuries and symptoms were reported for 712 injured persons (Table 3). Respiratory irritation was the most frequently reported injury/symptom for both students (27.8%) and non-students (39.9%). Gastrointestinal issues and eye irritation were the second and third most commonly reported injuries/symptoms for students. For nonstudents, eye irritation and headaches were the other most commonly reported injuries/symptoms (Table 3).

Discussion

This article, using HSEES/NTSIP public health surveillance data, describes a series of school chemical releases (n = 335) in 14 states. Even though chemical releases in schools represented a relatively small portion (1.3%) of releases in all locations, this report demonstrates that school chemical releases can cause serious public health consequences. A previous 10-year analysis of HSEES data (1999–2008) showed not only a large number of persons injured in educational institutions (NAICS code 6111), but also an increasing number of incidents in this sector (Orr, Wu, & Sloop, 2015).

Natural Gas

Natural gas was the most frequently reported chemical released in school settings. Adverse health effects from natural gas releases can be avoided by quickly establishing a means to detect and stop the release and ensure a rapid and orderly evacuation. Some natural gas incidents are the result of damaging or cutting utility lines due to construction. To prevent these incidents, workers should obtain information—prior to digging—about the location of underground utility lines and understand the rules and regulations pertaining to digging in certain areas (Common Ground Alliance, 2015).

The telephone number 811 has been nationally designated to eliminate confusion over multiple “Call Before You Dig” numbers across the country. Dialing 811 connects callers with local centers that notify the appropriate local utilities, who send crews to the requested site to mark the approximate location of underground lines at no charge. As natural gas incidents would not have been captured in HSEES unless another hazardous chemical was released at the same time, and only natural gas incidents with a public health impact would be included in NTSIP, the number of school natural gas incidents is likely to be underestimated.

Mercury

Mercury was the second most frequently reported chemical released in school settings. Mercury is found in a variety of products such as fluorescent light bulbs, thermostats, thermometers, barometers, and batteries (ATSDR, 2014). Exposure to mercury can result in adverse health impacts. The central nervous system is the body system most sensitive to exposure to mercury vapor, potentially resulting in memory loss, headache, sleeplessness, irritability, and tremors. Children are at an even higher risk because their nervous systems are still developing (ATSDR, 2011a). Schools can take several steps to mitigate the risk of mercury releases and the potential adverse effects from exposure. First, children and faculty can be educated about the dangers of mercury, especially because its unique properties make it attractive to children to play with. ATSDR has an interactive website called Don’t Mess with Mercury for children and teachers. The website has fact sheets, videos, games, and links to other resources that educate children and adults about the dangers of mercury and ways to properly remove mercury from schools (ATSDR, 2016b). In addition to identifying and disposing of mercury compounds and mercury-containing equipment, another way to reduce the potential for releases is by purchasing mercury-free products (U.S. EPA, 2016). Nineteen states have enacted legislation that bans or requires reduction of mercury in schools, and some states have regulations that restrict selling lamps that contain mercury to schools or that require schools to evaluate the uses of these lamps and seek alternatives.

Carbon Monoxide

Carbon monoxide (CO) was the third most frequently reported chemical released in school settings. To prevent CO releases in school settings, maintenance staff can frequently inspect and provide routine maintenance of vented combustion appliances, and schools can install carbon monoxide detector alarms (Raub, Mathieu-Nolf, Hampson, & Thom, 2000). Rules and regulations requiring CO detectors in schools vary from state to state (National Conference of State Legislatures, 2015). For more guidance about CO safety, schools can refer to the National Fire Protection Association. This organization can provide safety tips for preventing and/or reducing injuries and the severity associated with CO releases. For instance, they discuss the instructions on proper placement of CO alarms and what should be done to maintain CO alarms (National Fire Protection Association, 2017).

Pepper Spray

Chemical releases associated with pepper spray resulted in 78 injured persons. Most pepper spray incidents involved students intentionally releasing the substance (e.g., in pranks or fights). Preventive strategies can educate students about the health effects of pepper spray, including burns to the skin and eyes, coughing, and difficulty breathing (Hurley, 2013). As some pepper spray releases are a result of conflict, school authorities can teach students healthy, nonviolent ways to resolve conflicts with their peers.

Pool Chemicals

Pool chemicals were reported in 12 school chemical releases. The most commonly known pool chemicals are chlorine, hydrochloric/muriatic acid, and hypochlorite. Exposure to pool chemicals can result in serious health impacts, such as respiratory, eye, and skin irritation; gastrointestinal problems; and headaches. A majority of pool chemical releases are a result of human error (e.g., incorrectly adding chemicals to the pool) and equipment failure. Proper training for pool operators can prevent pool chemical releases and injuries associated with them. Routine maintenance of pool equipment can also help prevent releases and injuries (Anderson, 2015).

School-Based Prevention Strategies

To prevent and mitigate chemical releases in school laboratories, proper training of school administrators, teachers, and other school personnel, as well as adequately supervising students, can be key steps in effectively minimizing exposure (Landrigan et al., 1998). The U.S. Consumer Product Safety and Commission and Centers for Disease Control and Prevention’s (CDC) National Institute for Occupational Safety and Health developed a guide to reduce chemical exposures in school laboratories. This guide outlines responsibilities for teachers; safety dos and don’ts for students; and how to safely store, track, and dispose of chemicals and chemical waste from laboratories (U.S. Consumer Product Safety Commission, 2006).

Integrated chemical management (ICM) is an approach that establishes a central location where all laboratory chemicals at schools can be properly inventoried, stored, secured, and controlled (U.S. EPA, 2012). Some chemical releases that occur in school laboratory settings could be the result of spills from outdated and/or unknown chemicals being stored (U.S. EPA, 2011). To help remove outdated, unknown, and potentially harmful chemicals, in 2004 U.S. EPA developed the Schools Chemical Cleanout Campaign (SC3). SC3 is a national strategy that provides tools and resources for schools to use in their chemical cleanout programs (U.S. EPA, 2011).

Cleaning products and disinfectants can contain hazardous chemicals, such as ammonia, hydrochloric acid, and sodium hydroxide. Some acute adverse health effects associated with cleaning products and disinfectants include respiratory and skin irritation, gastrointestinal problems, and burns (Anderson, 2015). To minimize harmful effects, many schools have chosen to eliminate cleaning products with the most toxic ingredients and replace them with environmentally responsible choices. U.S. EPA’s Design for the Environment is a program that helps consumers, businesses, and institutional buyers identify cost-efficient and environmentally safer cleaning products and focuses on safely labeling disinfectants. Other certified programs include UL ECOLOGO and Green Seal, which are independent, third-party certification programs that recommend products that have minimal harmful effects on human health and the environmental (U.S. EPA, 2017b; An Act Concering Green Cleaning Products in Schools, 2009). Currently, 10 states and one district have green cleaning policies and/or recommendations for schools: Connecticut, Hawaii, Illinois, Iowa, Maine, Maryland, Missouri, Nevada, New York, Vermont, and Washington, DC (Environmental Law Institute, 2013). Although these states vary in the ways they establish criteria to implement policies and laws, they all use eco-certification to define green chemicals (ATSDR, 2014).

According to ICM, cleaning chemicals, such as laboratory chemicals, should be stored in a centralized location that is properly equipped with ventilation, security, and lighting for optimal safety. ICM involves a “pharmacy approach” that includes inventorying supplies; removing hazardous, outdated, and unnecessary products; proper labeling and recycling; and ensuring chemical security. The “pharmacy” is under the supervision of an “ICM gatekeeper” who maintains the chemical inventory, orders supplies, and verifies the safe condition of the area (U.S. EPA, 2012). For example, hydrochloric acid can cause eye, nose, and respiratory irritation, as well as heart problems (ATSDR, 2011b). In school settings, exposure to hydrochloric acid can occur in science laboratories and through contact with cleaning chemicals. Practicing ICM, in addition to properly wearing personal protective equipment, can mitigate hydrochloric acid releases and injuries associated with exposure.

Limitations

The HSEES/NTSIP data that were analyzed have some limitations. First, reporting school chemical releases might not be mandatory, so not all school chemical releases were reported to HSEES/NTSIP notification sources, resulting in some underreporting of school chemical releases. Second, with only 14 states represented, HSEES/NTSIP school chemical releases might not be nationally representative. Third, the number of injured persons and evacuations are an underestimation, due to underreporting of incidents. Finally, because of heightened concerns for children’s safety, evacuation and transport to medical facilities might have been more proactive in school chemical releases than similar releases in other locations, which might account for the disproportionately high numbers of reported evacuations and injuries and more frequent medical treatment of school children.

Conclusions

Our report shows that many resources and strategies are available to school administrators to prevent acute hazardous chemical releases. There are other environmental hazards at schools, such as asbestos and mold, which we are not able to address with our data; however, there are other resources available to schools to assist with the physical environment. For example, CDC periodically conducts surveys of policies and practices relevant to the school physical environment in school districts across the U.S. through the School Health Policies and Practices Study (Everett Jones, Smith, Axelrad, & Wendel, 2012). In addition, the U.S. EPA has developed State School Environmental Health Guidelines (U.S. EPA, 2017c), voluntary School Siting Guidelines (U.S. EPA, 2017d), and a Model School Environmental Health Program (U.S. EPA, 2016b) as free resources to improve health and wellness of school students and staff. Also, the U.S. Department of Education has implemented a Green Ribbon Schools award program, another resource for enhancing health and wellness in school settings (U.S. Department of Education, 2015). Another resource that is available regionally throughout the U.S. are the Pediatric Environmental Health Specialty Units (PEHSU). These units are based in academic-affiliated medical centers and are staffed by healthcare providers with expertise in issues related to pediatric and reproductive environmental health. Their faculty and staff work closely with local, state, and federal health officials, consulting on a variety of environmental issues involving the health of children and their families. PEHSU personnel can advise school district leadership, local school committees, and local boards of health about the properties and potential health effects of chemicals stored and used on school properties, and explain the safety measures that should be considered to address and remediate potentially hazardous situations (PEHSU, 2017).

Despite the various resources available, acute chemical releases continue to occur in school settings. The adverse public health consequences associated with school chemical releases highlight the need for enhanced collaboration among public health and environmental agencies, individual schools, school boards, parent and teacher organizations, and elected officials in ensuring best practices are used. Additionally, there is a need for future tracking of acute chemical releases in school settings and the health outcomes associated with such releases. Tracking chemical releases can help schools allocate limited resources for promoting health in the school environment.

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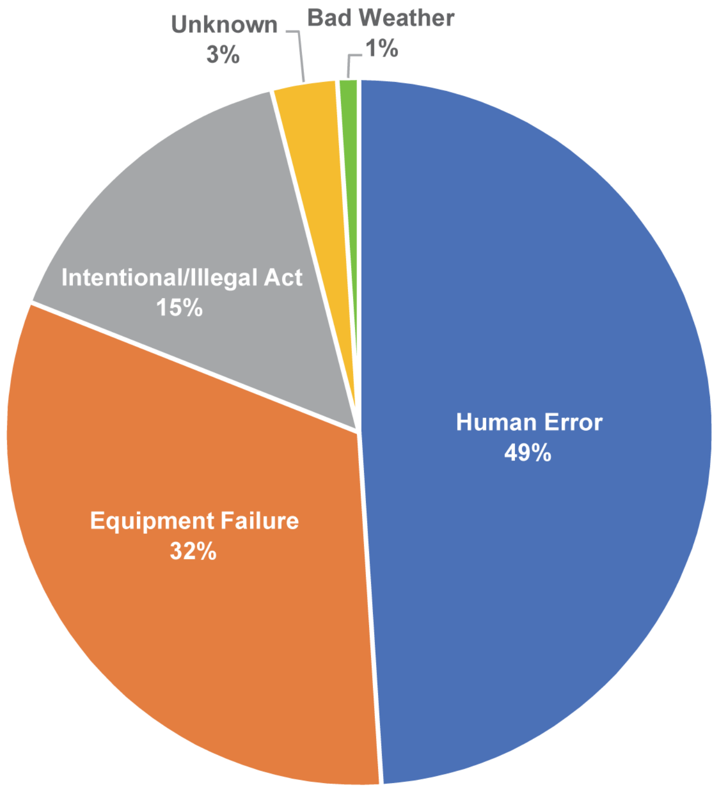

FIGURE 1.

Distribution of Contribution Factors That Were Associated With School Chemical Releases, Hazardous Substance Emergency Event Surveillance/National Toxic Substance Incidents Program, 2008–2013 ($N = 335$)

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TABLE 1

Summary of School Chemical Incidents Compared With Nonschool Incidents, Hazardous Substances Emergency Event Surveillance/National Toxic Substance Incidents Program, 2008–2013

Category	School Chemical Incidents	Nonschool Incidents	Total
Incidents	335	24,413	24,748
Evacuations ordered	192 (57.3%)	3,171 (13.0%)	3,363 (13.6%)
Total people evacuated[a]	47,433	104,985	152,418
Median number of people evacuated (range)	305 (2–3,000 evacuees/incident)	17 (1–15,000 evacuees/incident)	20 (1–15,000 evacuees/incidents)
Total evacuation hours[b]	2,689	17,145	19,834
Median hours of evacuations (range)	2 (15 min–1,392 hr)	2 (15 min–2,664 hr)	2 (15 min–2,664 hr)
Incidents with injured persons	119 (35.5%)	3,173 (13.0%)	3,292 (13.3%)
Injured persons	712	7,644	8,356
Median number of injured persons (range)	2 (1–61 injured persons/incident)	1 (1–54 injured persons/incident)	1 (1–61 injured persons/incident)

[a]Number indicates the number of known evacuees. When large areas were evacuated, not all evacuees could be counted, so the number for evacuees is an underestimate.

[b]Number indicates the reported time frame for evacuations (reported to the nearest quarter hour). Not all incidents that reported evacuations included time frame of evacuation, so total hours of evacuations is an underestimate.

TABLE 2

Summary of Top Five Chemicals Released in School Settings, Hazardous Substance Emergency Event Surveillance/National Toxic Substance Incidents Program, 2008–2013

Substance	Incidents # (%)	Incidents With Evacuations # (%)	Total People Evacuated # (%)	Incidents With Injured Persons # (%)	All Injured Persons # (%)
Overall totals	335	192	47,433	119	712
Natural gas	73 (21.8)	66 (34.4)	13,738 (29.0)	3 (2.5)	3 (0.4)
Mercury	61 (18.2)	32 (16.7)	7,362 (15.5)	3 (2.5)	10 (1.4)
Carbon monoxide	21 (6.3)	16 (8.3)	6,754 (14.2)	7 (5.9)	143 (20.1)
Hydrochloric acid	14 (4.2)	4 (2.1)	650 (1.4)	11 (9.2)	43 (6.0)
Pepper spray	13 (3.9)	8 (4.2)	2,950 (6.2)	10 (8.4)	78 (11.0)

TABLE 3

Disposition and Symptoms of Injured Persons Comparing Students With Nonstudents in School Chemical Releases, Hazardous Substances Emergency Event Surveillance/National Toxic Substance Incidents Program, 2008–2013

	Students # (%)	Nonstudents[a] # (%)	Total # (%)
Injured person disposition			
Treated at hospital (not admitted)	282 (63.8)	126 (46.7)	408 (57.3)
Treated on scene	62 (14.0)	27 (10.0)	89 (12.5)
Observation at hospital, no treatment	47 (10.6)	4 (1.5)	51 (7.2)
Treated at hospital (admitted)[b]	22 (5.0)	40 (14.8)	62 (8.7)
Treated at hospital (admittance unknown)	17 (3.9)	55 (20.4)	72 (10.1)
Seen by private physician	8 (1.8)	10 (3.7)	18 (2.5)
Injury reported by official	4 (0.9)	8 (2.9)	12 (1.7)
Total	442 (100)	270 (100)	712 (100)
Injury/symptoms type			
Respiratory irritation	174 (27.8)	155 (39.9)	329 (32.5)
Gastrointestinal issues	107 (17.1)	21 (5.4)	128 (12.6)
Eye irritation	98 (15.7)	67 (17.3)	165 (16.3)
Other	59 (9.4)	32 (8.2)	91 (9.0)
Headache	56 (9.0)	33 (8.5)	89 (8.8)
Dizziness/central nervous system issues	54 (8.6)	31 (8.0)	85 (8.4)
Burns	29 (4.6)	23 (5.9)	52 (5.1)
Chemical	23	13	36
Thermal	1	3	4
Both	3	1	4
Unknown	2	6	8
Skin irritation	28 (4.5)	13 (3.4)	41 (4.0)
Shortness of breath	17 (2.7)	4 (1.0)	21 (2.1)
Trauma	3 (0.5)	7 (1.8)	10 (1.0)
Chemical	2	1	3
Nonchemical	0	4	4
Unknown	1	2	3

	Students # (%)	Nonstudents[a] # (%)	Total # (%)
Heat stress	0 (0)	2 (0.5)	2 (0.2)
Total[c,d]	625 (99.9)	388 (99.9)	1,013 (100)

[a]Nonstudents include employees, general public, and responders.

[b]Includes those who were observed and treated at hospital.

[c]Some totals do not equal 100 due to rounding.

[d]Injury type numbers may be higher than injured person numbers because some people reported multiple injuries.